Sand Dune and Shingle Network

New Horizons 2025

Pioneering Research in Dunes and Shingle

Book of Abstracts

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The Sand Dune and Shingle Network

Sand Dune and Shingle Network

The Sand Dune and Shingle Network operates with the support of a memorandum of understanding between Liverpool Hope University, National Trust, Natural England, Cyfoeth Naturiol Cymru (Natural Resources Wales), NatureScot, The Department of Agriculture, Environment and Rural Affairs (DAERA), Kenneth Pye Associates Limited and Oleo Ecology.

The principle aims of the Sand Dune and Shingle Network is to build upon the momentum established by Dynamic Dunescapes, Sands of LIFE and Dynamic Coast, to promote landscape-scale, collaborative and evidence-based ways on managing our sand dune, machair and shingle habitats.

Through encouraging better communication and active debate involving a range of disciplines, the Sand Dune and Shingle Network aims to build capacity and capability for delivering best practice habitat management, promote an ecosystems approach to site management, and thereby supporting delivery of national commitments and targets.

Within the UK, the Sand Dune and Shingle Network supports co-operation and co-ordination of approach across the devolved administrations, in the absence of an operating Coastal Lead Co-ordination Network, maximining our collective impact.

To register your interest in joining the Network, please complete the online membership form or contact us at dunes@hope.ac.uk. Further information about membership can be found on our website https://coast.hope.ac.uk/jointhenetwork/.

Cover image: Kenfig Pool and Dunes National Nature Reserve, Wales. (Photo: Thomas Smyth)

New Horizons Conference 2025

22 January 2025

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Welcome Message

Thomas Smyth and Paul Rooney, School of Computer Science and The Environment, Liverpool Hope University

On behalf of the Sand Dune and Shingle Network, it is our great pleasure to welcome you to the inaugural *New Horizons in Dunes and Shingle* conference. This event marks the beginning of what we hope will become a long-standing tradition of showcasing the innovative work of PhD candidates and early-career researchers who are advancing our understanding of coastal dune, machair, and shingle environments.

We are delighted to have over 100 registered attendees joining us, representing more than 10 countries, and look forward to the lively discussions, knowledge exchange, and collaborations that will emerge during the event. Many of the talks presented at this conference are also available to watch on our YouTube page, and links to the relevant recordings can be found at the bottom of the corresponding abstracts.

Thank you for being part of this exciting moment for the network. We hope you enjoy the conference and take the opportunity to connect with fellow attendees.

Thomas Smyth and Paul Rooney
Sand Dune and Shingle Network

Foredune Notches: Uptake, description and constructed variability of a new coastal dune habitat management method

Thomas Pagon, School of Applied Sciences, University of Huddersfield
Thomas Smyth, School of Computer Science and the Environment, Liverpool Hope University
Ryan Wilson, School of Applied Sciences, University of Huddersfield, UK
Bethany Fox, School of Applied Sciences, University of Huddersfield, UK.

Globally, coastal sand dunes have experienced an increase in vegetation cover over at least the last century due to a variety of factors, including climate change and changes in land use. This increase in vegetation has led to coastal sand dunes becoming “fixed” and a decrease in bare sand and early successional stage habitats within dune systems, especially in Europe. Foredune notches are a management intervention that aims to address these challenges by facilitating wind-blown sand transport to the middle and back dune areas. While individual site-specific studies have researched various elements of these features, there is limited research on the broader adoption of these notches and their variability in design and, therefore, their geomorphic functioning.

In this study, we identified and analysed 133 foredune notches globally using aerial imagery to explore variations in design at construction. The findings reveal considerable differences in notch dimensions, with those in France and New Zealand being smaller on average compared to larger and more varied designs in the UK and the Netherlands. These differences in length and width, particularly pronounced in the Netherlands, remain underexplored in existing literature. To complement these findings, we analysed ten years of remotely sensed data from Europe and New Zealand to investigate how constructed morphology influences the long-term evolution and persistence of these features. Initial results show that variations in notch design significantly impact spatial changes and longevity, underscoring the importance of design in achieving the outcomes desired by land managers.

Based on these insights, we propose a new classification framework for foredune notches, emphasizing their constructed morphological characteristics. This system provides a transferable and consistent method for describing these features, enabling more effective comparisons across sites and, therefore, research. By improving the clarity and consistency of notch design descriptions, this framework supports site managers in making informed decisions, fostering the creation of more resilient coastal habitats and enhancing the overall effectiveness of dune management strategies.

Watch the full presentation online: https://youtu.be/7IR92TRoRw0

Improving soil conditions in response to notch creation and dune slack reprofiling in Wales

Maud A.J. van Soest, Laurence Jones

Coastal sand dune systems are critical habitats supporting diverse ecosystems, ranging from mobile bare sands to stable vegetated areas and low-lying dune slacks. However, increasing stabilisation of these systems in western Europe has led to habitat degradation and reduced species diversity. The Sand of Life restoration project implemented management interventions, including dune slack re-profiling and notch creation, across six dune sites in Wales, UK, to restore sand mobility and promote early successional habitats.

Post-intervention monitoring revealed notable outcomes for soil conditions in re-profiled dune slacks. Organic matter and nitrogen contact were substantially reduced, with most intervention sites showing little to no residual organic material. While most sites displayed uniform sandy profiles, Kenfig and Tywyn Aberffraw retained a slightly organic surface layer due to purposefully shallow scrapes. Bulk density (BD), pH, and calcite increased significantly, reflecting the removal of partially decalcified and organic-rich surface layers. These changes align with early successional soil characteristics, favouring colonisation by pioneer plants.

For notch creation, sand-rain monitoring indicated increased wind-deposited sand at some sites, particularly Tywyn Aberffraw and Merthyr Mawr. Higher BD, pH, and calcite values, coupled with reduced organic matter, were attributed to fresh sand influx burying older soil layers. At Tywyn Aberffraw, the intervention (notch) transect contained higher BD, pH, and calcite and lower LOI, EC than the control along the transect, with substantial sand blow recorded at the 50 m location. At Merthyr Mawr, the 50 m intervention transect location received substantially more fresh sand than other locations, and the soil chemistry reflects this, but there were no clear increasing or decreasing trends in sand volume with distance nor substantial differences between intervention and control.

No substantial changes in wind-deposited sand were obtained at Kenfig, constrained by geomorphology as the beach is below cliffed dunes. The low levels of blown sand here reflect the patterns shown in the pre-intervention monitoring phase. There were no clear differences at Pembrey because of unplanned disturbance that affected lobations both inland of the notch and adjacent to the control transect. The main particle modes were around 200 µm at all sites and clay and silt contents <8%. The patterns between distances along the transects in the pre-intervention phase were reflected in the results obtained in the post-intervention phase. For example, the control transect at Kenfig showed greater sand blow than the intervention transect during the pre-intervention monitoring which helped understand the similar results seen in the post-intervention data. This shows the importance of both baseline data pre-intervention, and of control locations which help draw robust conclusions from the analysis.

Overall, the results suggest that the interventions have been successful in promoting sand mobility and altering soil chemistry in some areas, towards the desired conditions for early successional stages. However, the varying wind conditions, intervention scales, and pre-existing geomorphological settings have resulted in differences in these outcomes across sites. Repeated and large-scale interventions may be required to sustain habitat conditions and unsure long-term success. Continuous monitoring will be crucial for evaluating trajectories and refining restoration strategies.

Watch the full presentation online: https://youtu.be/rdTWq4LuSX0

Rethinking coastal vulnerability indices for Nature-based Solution applications in Ireland

Silvia Cascone, University of Galway, Ireland
Kevin Lynch, University of Galway, Ireland
Terry Morley, University of Galway, Ireland

The Northwest of Ireland represents a high-energy environment where wind and waves strongly shape the features and aspect of the coastline. Coastal dunes are dynamic systems that can play an important role as Nature-based Solutions (NbS) to minimise the impacts of climate change and storm surges. This function is strictly linked to the state/health of the system and is consequently influenced by physical, biotic and anthropic pressures. The concept of vulnerability is often used to assess the state of a dune system and can be applied to prioritise sites in need of active management actions. However, a comparable standard methodology is not yet available, and the lack of context-specific data imposes a challenge for the implementation of local NbS actions. As a matter of fact, when the main natural and anthropic drivers differ between sites, the selection of a set of suitable indicators is a challenging task that can hinder the assessment process.

We selected 13 sites in the Northwest of Ireland and tested a modified version of the Dune Vulnerability Index (Garcia-Mora et al., 2011) to determine the level of vulnerability of each site and the strongest drivers involved. One of the main challenges is to focus on indicators able to simplify the complex network of interactions and disturbances present in these environments which also have the potential to change over time in response to management strategies. The index was modified with the objectives of including only quantitative indicators, minimising correlation between parameters, reducing the number of indicators and focusing on a local scale.

Results suggest that the implemented quantitative index can be a useful tool to prioritise sites in need of intervention. In addition to this, it has the potential to highlight the main drivers responsible for the different vulnerability levels which can be translated into practical information when planning a restoration project. “Working with natural processes” at a local scale is a crucial step to improve conservation actions and to develop Nature-based Solution strategies adapted to Ireland’s context.

A case study of land cover and geomorphology changes (1951–2023) in Sheskinmore, a coastal dune site in northwest Ireland

Yixuan Chang, University College London, London, UK
Helene Burningham, University College London, London, UK

This case study investigates land cover and geomorphological changes in a coastal dune system in northwest Ireland over seven decades (1951–2023). Utilizing a combination of historical aerial imagery, Sentinel-2 satellite data, and image processing techniques, the research explores the dynamics of land cover transitions and their relationship to coastal processes, climate change, and anthropogenic impacts. Detailed geomorphological mapping was conducted for 1951, 2000, 2012, and 2023, while land cover was classified at three-year intervals using a customized algorithm. The findings reveal significant development in vegetation cover, while the physical landscape remains relatively stable, with the dune system showing minor signs of erosion but major shifts in coastal boundaries. As a representative example of coastal systems in northwest Europe, this case study of Sheskinmore emphasizes the importance of long-term monitoring and interdisciplinary approaches to studying coastal geomorphology and land cover dynamics.

Watch the full presentation online: https://youtu.be/jybH_qR2WWQ

Assessing loss of California's coastal dunes using historical maps and machine learning tools

Timothy Baxter*, Jenifer Dugan*, Kyle Emery*, Laura Engeman^, Dakota Fee*, David Hubbard*, Karina Johnston*, Andrea Pickart", Sarah Smith*, Ian Walker*, Dan Willet*, Jenna Wisniewski^

*University of California, Santa Barbara, California, USA.
^ Scripps Institute of Oceanography, University of California, San Diego, California, USA.
" U.S. Fish and Wildlife Service, Arcata, California, USA

California's sandy beaches provide multiple benefits to communities, economies and ecosystems. These highly valued spaces are increasingly threatened by climate change with recent projections suggesting between 20–75% could disappear by 2100. Coastal dunes provide a protective buffer against flooding and erosion, enhancing the resilience of adjoined beaches and estuarine environments to climate forcing. Yet, a comprehensive assessment of the condition, extent and vulnerability of coastal dunes is currently lacking in California. As part of a larger project evaluating the value of coastal dunes as 'nature-based solutions' against climate change, this study provides the first statewide assessment of current and historical sand dune extent and loss since 1851.

The location and height of key dune features (i.e. toe, crest, landward extent) were determined using high resolution satellite imagery, NDVI and LiDAR data in combination with HAML DAT—Human Attenuated Machine Learning Dune Annotation Tool—a novel ArcGIS tool used to delineate coastal dune formations. Rates of loss were then determined by comparing the extent of existing dunes to an inventory of historical dunes created through the digitization of early topographic maps. These results were then verified during field campaigns and targeted workshops with local conservation professionals and end-users.

Our findings suggest that ~27% of California's coastline is dune backed. This represents a significant decrease compared to the end of the 19th century, with coastal development, land use change, and invasive species causing the degradation and loss of many dune systems. Highly urbanized areas in southern California have experienced the greatest rates of loss, with more than 98% of dunes lost in some regions (e.g. LA County). More research is now required to understand the geomorphology and ecology of these systems to help inform future restoration efforts and local-scale resilience planning.

Watch the full presentation online: https://youtu.be/l0ly_vj_RbM

Assessing Marine Litter on Coastal Dunes: New Monitoring Approaches and Key Insights

Umberto Andriolo,INESC Coimbra, University of Coimbra, Coimbra, Portugal
Gil Gonçalves, INESC Coimbra, University of Coimbra, Portugal

Marine litter (or marine waste) consists of items that have been either deliberately discarded or unintentionally lost. Transported by winds and rivers, litter eventually ends up in the sea or strands on coasts. The abundance of litter in the environment has become a global issue, as it can negatively affect coastal ecosystems, harm humans, and threaten marine life. Over the past two decades, litter monitoring strategies have been implemented on coastlines to identify the most common items and support efforts to mitigate pollution. Traditional approaches involve visual censuses conducted on beaches, with personnel counting and characterizing litter across a limited transect of the beach. While data on beached litter are widely available, there has been much less attention given to litter pollution on coastal dunes.

This study presents a novel framework that employs a drone and a GIS mobile application to map macrolitter (>2.5 cm) in coastal dune environments. A multirotor quadcopter was used to acquire high-resolution aerial images of the Quiaios dunes (Portugal). Litter items were identified in the orthophotos to create a litter map. The GIS mobile application was used in the field to finalize the litter classification. The analysis allowed for: i) characterizing the level of pollution in the dunes, ii) describing the spatial distribution of litter across the dune sectors, and iii) identifying potential litter pathways. In the monitored area (200 m × 80 m, 16,000 m^2), a total of 402 items were found, 76% of which were plastics. About 36% could be attributed to fishing activities, while 39% were associated with recreational activities. Regarding the cross-shore distribution, the highest number of items was found on the foredune, decreasing landwards. The percentage of plastic items increased from 60% to 90% landwards. The largest items (processed wood) were found on the embryo dune. Recreation-related items (such as plastic bottles and paper napkins) were mostly trapped by the foredune grass, while the low scrub plant community intercepted longer and larger fishing-related items on the backdune.

On the longshore, litter abundance increased with distance from the last beach access, with the number of fishing-related items rising from the urbanized area towards the more natural coast. Three main accumulation points were identified in correspondence with dune blowouts and trails. This indicates the significant role of wind and overwash events in dune contamination, and suggests that dune ridge restoration could serve as a mitigation measure to prevent stranded litter from being transported through blowouts.
Finally, we documented plastics up to 38 years old that had been exhumed from the storm-eroded foredune, and described how litter items interact with the natural processes of seasonal dune growth and erosion. Therefore, this study aims to provide a new perspective on litter monitoring in coastal dunes, where the long residence time of marine debris poses a threat to the ecological balance of these ecosystems.

Watch the full presentation online: https://youtu.be/YQ0jwG9DwWA

Air flow and sand transport perturbation over a human-made fore-dune under offshore wind using computational fluid dynamics

Antoine Lamy CEFREM, Université de Perpignan Via-Domitia, Perpignan, France
Thomas Smyth Department of Geography and Environmental Science, Liverpool Hope University, England, UK
Nicolas Robin CEFREM, Université de Perpignan Via-Domitia, Perpignan, France
Patrick Hesp Beach and Dune Systems (BEADS) Laboratory, College of Science and Engineering, Flinders University, Bedford Park, Australia

Coastal dunes provide many environmental services including protection from wave erosion and inundation during storm events. Human activities grew rapidly until the 20th century in European coastal areas, disturbing the natural evolution of coastal dunes. These alterations occurred through dune stabilisation by vegetation planting or reshaping the dune profile, resulting in a modification of the air flow and sediment transport patterns. For example, a taller and steeper dune may result in an increased zone of wind flow separation and deceleration, causing the reversal of flow and sediment transport to the dune toe from the backshore during offshore winds (Walker and Nickling, 2002; Hesp and Smyth, 2019). Globally, the pattern of reversed or deflected flow plays a key role in dune evolution, particularly when an offshore wind regime is dominant (Bauer et al., 2012; Nordstrom and Jackson, 2018). While the impact of human interventions on the short-term evolution of coastal dunes is reasonably well understood, less is known about their contemporary influence on current wind and sediment dynamics several decades after implementation. The coastal dune in Leucate (South of France) is dominated by strong offshore winds (70 % of the time and 17.5 % > 10 m/s) and it have been anthropogenically constructed since 2003. The dune system is composed of a single foredune and is vegetated from the dune crest to the inland. The northern part of the dune has a symmetrical profile with a 28° stoss slope, 30° lee slope and a single crest. The southern part is asymmetric, with a gentler stoss slope (12°), 26° lee slope, and a double crest. Recently, Computational Fluid Dynamics (CFD) has given new insights to complex flow recirculation on the lee side of heavily managed coastal dunes on developed coasts during onshore winds (Smyth and Hesp, 2015; Nguyen et al., 2022). To explore the potential geomorphic impacts of this distinct difference in morphology, several numerical simulations with varying wind speeds and direction were conducted using the CFD tool Open Foam. The results show that, near surface wind speed accelerated toward the dune crest on the windward slope of the dune, with different pattern depending on the dune shape. This speed-up is higher during perpendicular wind. Wind flow separation was observed only during perpendicular wind on the southern lee slope (where the steeper lee slope is observed) and with limited lateral extension. This reversed flow was below the threshold for aeolian sediment transport, even under strong incident wind (20 m/s). Elsewhere in the lee of the dune, the wind was only deflected by an order of 15° for the oblique winds, and less than 10° for the perpendicular wind on the southern part. The shear velocity exceeded the threshold, notably on the southern dune, which coincided with the formation of undulating aeolian deposits in the lee of vegetation on the dune crest. The spatial differences observed in wind flow and aeolian sediment transport processes on this human-made dune were directly inherited from differences in their construction two decades ago.

Watch the full presentation online: https://youtu.be/pxZE3FFQxjM

Morphological Evolutions Shaped by Dual Wind Regime Across a Small Trough Blowout Altered by Pathway

Camille René, CEFREM, Université de Perpignan Via-Domitia, Perpignan, France
Nicolas Robin CEFREM, Université de Perpignan Via-Domitia, Perpignan, France
Thomas Smyth Department of Geography and Environmental Science, Liverpool Hope University, England, UK
Patrick Hesp Beach and Dune Systems (BEADS) Laboratory, College of Science and Engineering, Flinders University, Bedford Park, Australia
Antoine Lamy CEFREM, Université de Perpignan Via-Domitia, Perpignan, France
Olivier Raynal CEFREM, Université de Perpignan Via-Domitia, Perpignan, France

European dunes systems have experienced substantial anthropogenic changes in recent decades, leading to topographic weaknesses that often trigger blowouts, a common erosional feature in coastal dunes. This study examines a site in SE France, within a microtidal environment influenced by contrasting wind regimes (offshore/onshore). The site includes two small naturally evolving trough blowouts and one blowout altered by human footpaths. This blowout exhibits a complex morphology with trough axis divided into two sections: section 2a (landward, WNW) and section 2b (seaward, NNW). Using multi-year LiDAR (2009, 2014, 2020) and UAV surveys (2024), the study tracks the long-term evolution of these features. Additionally, Aeolian processes were analysis during two contrasting wind regimes through daily campaigns, employing anemometers, sediment traps and UAV surveys. The findings aim to elucidate the mechanisms driving the differing evolutionary trajectories of these dune systems.

The multi-year analysis reveals the natural initiation and rapid landward extension of blowouts driven by onshore winds. One of three blowouts connected with a closed footpath before 2014, haltering further elongation and forming an elbow-shaped morphology. Thus, section 2a is aligned with the footpath bifurcate to section 2b oriented along the bidirectional wind regime. In contrast, the other two blowouts continued developing in the onshore direction. Sand sheet deposits suggest that the altered blowout is slowly attempting to re-establish a natural trajectory. Aeolian processes and topographic changes highlight spatial differences linked to wind direction regime. During offshore winds, section 2a experiences oblique flow, creating low-velocity turbulence. It reached its maximum in the constricted throat region, then bifurcated into section 2b aligned with the incident winds that allows acceleration. Sediment transport remains minimal (<15 kg/m/h) due to a vegetated upstream fetch and coarse grain size (>1000 µm), limiting sediment mobilization. Offshore winds inhibit the formation of a depositional lobe as they blown towards the berm, where the maximum transport is recorded. Thus, there are only a few erosion zones located landward, where variations were modest (<0.20 m). Under onshore winds, elongation is expected along section 2b with a depositional lobe. However, topographic steering into section 2a reduces wind speed, leading instead to an accumulation zone inside the blowout. Sediment transport rates were higher (reaching 84 kg/m/h) due to bare sand fetch, with more pronounced topographic variations along the external walls, where finer sand (<500 µm) dominate. These results demonstrate that onshore winds are key to shaping the blowout, despite the dominance of offshore winds. Anthropogenic impacts have altered its natural evolution, yet sand sheets landward of section 2b suggest partial recovery. The blowout appears to be progressing returning to a natural dynamic, though at a much slower pace, reflecting the long-lasting effects of past human actions.

Watch the full presentation online: https://youtu.be/bHPUCpdOFB0?si=bnbJo8bx2RdbW3fB

Multi-annual evolution of the Pilat dune, southwest France

Jules Buquen, BRGM French Geological Survey, Regional Direction Nouvelle-Aquitaine, 24 Avenue Léonard de Vinci, 33600 Pessac, France and Université de Bordeaux, CNRS, Bordeaux INP, EPOC, UMR 5805, F-33600 Pessac, France.
Alexandre Nicolae-Lerma, BRGM French Geological Survey, Regional Direction Nouvelle-Aquitaine, 24 Avenue Léonard de Vinci, 33600 Pessac, France.
Bruno Castelle, Université de Bordeaux, CNRS, Bordeaux INP, EPOC, UMR 5805, F-33600 Pessac, France.
Vincent Marieu, Université de Bordeaux, CNRS, Bordeaux INP, EPOC, UMR 5805, F-33600 Pessac, France.
Olivier Burvingt, Université de Bordeaux, CNRS, Bordeaux INP, EPOC, UMR 5805, F-33600 Pessac, France.
Nicolas Robin, CEFREM, UMR CNRS 5110, Université de Perpignan Via-Domitia, Perpignan 66860, France

The Pilat dune, located along the southwest coast of France, is the highest (>100-m elevation) coastal dune in Europe. This high dune is mostly unvegetated and is characterized by large morphological changes over the past decades, threatening adjacent infrastructures and coastal road. Although this dune is world-famous because of its height, only few studies have been made to understand its morphodynamics in the past, mainly due to the lack of data. Indeed, a comprehensive analysis of the different morphological change patterns observed along this 900 m wide, and 3000 m long dune requires extensive topographic datasets.

The objective of this study is to understand the morphodynamics of the Pilat dune by quantifying multi-annual variations of the dune volume, and in dune foot, mid-slope and crest positions. Using 10 high-resolution airborne LiDAR datasets collected annually between 2011 and 2024, the dune topography was interpolated onto a 1-m resolution regular local grid in cross-shore/longshore coordinates. Based on an analysis of several morphological parameters (e.g. dune crest), the dune was also divided in four zones with uniform behaviour. Results showed a significant and alongshore variable landward migration of the Pilat dune over the study period. Morphological changes in the region of the dune crest showed contrasting behaviours, either slightly increasing or decreasing, and a strong interannual variability that is mostly related to the complex dynamics of medium size superimposed dunes, relatively small vegetation patches, and the broad morphology of the dune.

These findings highlight the large spatial and temporal morphological variability of the Pilat dune, emphasizing the need for a segmented dune analysis over different zones with distinct morphodynamic behaviours. This work, based on field data, is valuable for the understanding of the Pilat dune dynamics and will also be used for the application of numerical morphodynamic models based on aeolian transport.

Watch the full presentation online: https://youtu.be/a8Q9EtJHsf0

Understanding Embryo Dune Dynamics

Matthew Withers, University of Huddersfield, Huddersfield, UK.

Coastal foredunes play a vital role in delivering ecosystem services, such as coastal flood protection and providing habitats for diverse endemic and endangered species. The earliest stage of foredune formation involves embryo dunes (also known as incipient dunes), which develop through complex interactions between windblown sediment, vegetation, and marine erosion processes. With increasing sea level rise, coastal dunes are gaining recognition as effective nature-based solutions for mitigating flooding and erosion while also reducing nuisance windblown sand.

This study investigates embryo dune development at two UK sites: Sutton-on-Sea on the east coast and Fylde on the west coast of England. Using a multi-decadal dataset combining historical LiDAR, aerial imagery, and meteorological records, we analysed changes in sediment volume, vegetation, and dune profiles over ~20 years.

The findings reveal that site-specific management practices were the primary drivers of embryo dune evolution, resulting in the development of distinct topographical features at each location. By providing insights into the factors shaping embryo dune dynamics, this research offers valuable guidance for decision-makers on leveraging these dynamic features as sustainable coastal management tools.